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instruction manual

INSTRUCTION MANUAL

MODEL 7580
TRANSFER OSCILLATOR

Beckman®

Berkeley Division

STABRO LABORATORIES, INC.
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Chris Warren
DOCUMENT CONTROL ADMINISTRATOR

INSTRUCTION MANUAL

MODEL 7580
TRANSFER OSCILLATOR

Serial #65

NOTE

If model number is followed by one or more letters, the instrument covered by this manual has been modified. See section on modifications.

Beckman/ Berkeley Division
Richmond 3, California

August 1959

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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DRAWINGS

Power Supply, Dwg. No. 7580 C 1
Beat Frequency Indicator, Dwg. No. 7580 D 2
Oscillator and Multiplier Chain, Dwg. No. 7580 D 3
Time Base Multiplier and Oscillator Binary, Dwg. No. 7580 D 4

1.1 GENERAL DESCRIPTION

1.1.1 Purpose

The Model 7580 transfer oscillator is designed to be used in conjunction with a Model 7360J or 7370 counter to measure frequencies ranging from DC to 12,000 mc. The instrument will accommodate several types of RF signals, including continuous fixed frequency signals with or without amplitude modulation, frequency-modulated signals and pulsed RF signals. All signals may contain considerable noise without affecting the ease or accuracy of measurement.

The transfer oscillator can be operated in conjunction with other specially-modified BECKMAN frequency counters; however, all information in this manual applies to use with Models 7360J or 7370. If used with other counters, see the counter instruction manual for directions.

1.1.2 Principle of Operation

The transfer oscillator generates a fundamental frequency which may be varied within two ranges: from 7.5 to 15 mc and from 75 to 150 mc. It also generates all harmonics of this fundamental up to and beyond the 70th. To measure the frequency of an input signal, the fundamental is adjusted to the point where one of its harmonics has the same frequency as the input signal. This is done by beating the harmonic against the input signal and varying its frequency until the difference frequency, as observed on a built-in oscilloscope, is zero. Then, a frequency equal to the fundamental divided by a power of 10 is fed to the counter. Now, if the counter counted each cycle of this signal for .01, 0.1 or 1 second, the fundamental frequency would be displayed. To find the input frequency, then, we would multiply this indication by the harmonic number, N. To avoid this calculation, the counting period is expanded to N times the usual decimal period, with the result that the input frequency appears directly in decimal digits on the face of the counter.

Determining the harmonic number is likewise accomplished without calculation, in most cases. The operator simply locates two adjacent fundamentals, each of which produces a harmonic equal to the input frequency, then reads the harmonic number of the lower fundamental on a scale. The scale is a simple mechanical analog computer like a slide rule. It solves the equation:

$$N = \frac{f_L}{f_H - f_L} + 1$$

where f_L = lower fundamental frequency

f_H = higher fundamental frequency

N = number of harmonic of f_L

Figure 1 shows the essential parts of the system.

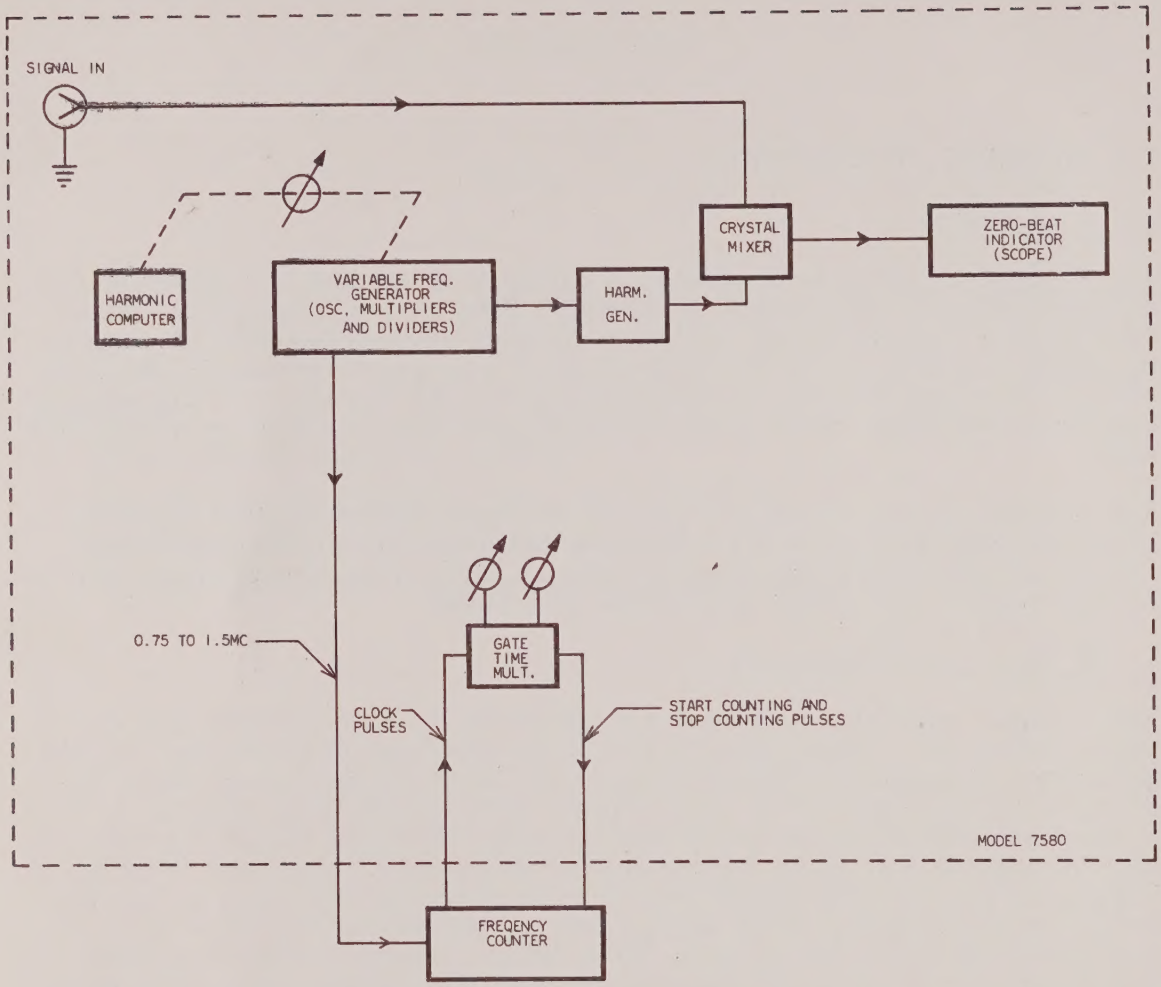


FIGURE 1. SIMPLIFIED BLOCK DIAGRAM

1.2 SPECIFICATIONS

1.2.1 Entire System (Transfer Oscillator Plus Frequency Counter)

Frequency Measuring Range: DC to 12,000 mc.

Type of Input Signal Which Can Be Measured:

Continuous, fixed-frequency signals with or without amplitude modulation.

FM signals.

Pulsed RF signals.

Required Input Amplitude: Never more than 100 mv rms, usually much less. See typical sensitivity curve, figure 3. Source impedance should be about 50 ohms.

Accuracy of Measurement: Depends upon input signal. See section 2.6 "ACCURACY".

1.2.2 Transfer Oscillator

Fundamental Signal:

Frequency: Continuously variable within two ranges: from 7.5 to 15 mc and from 75 to 150 mc.

Frequency Stability: .0001 percent per minute.

Tuning Mechanism for Fundamental Signal

Dial Calibration: Increments of 1 kc on 7.5 to 15 mc range.
Increments of 10 kc on 75 to 150 mc range.

Accuracy of dial setting: 0.1% of fundamental frequency.

Repeatability of dial setting: .005%.

Tuning Rate:

Main control: High gear: traverses full range in 12 turns.
Low gear: traverses full range in 100 turns.

Electrical vernier: Varies fundamental frequency approximately ±.015%.

Harmonic Signal: All harmonics of fundamental signal through the 80th are usable.

Signal to Counter: Frequency: 0.75 to 1.5 mc.
Amplitude: 1 volt rms.
Output Impedance: 1000 ohms.

Beat Frequency Amplifier.

Bandwidth: 1 kc to 1 mc. Equipped with controls to reduce response at high or low end.

Output Signal: 1 v. rms out of 1000 ohms.

Built-in Oscilloscope for Displaying Beat Frequency.

Size: 2 inches in diameter.

Internal sweep: 60 cps sine wave with phase control.

(NOTE: Provision for external sweep is available on option.)

Power Requirements: 117 v. ±10%, 50 to 60 cps, 175 watts.

Dimensions: (without cabinet) 8 3/4 in. high, 19 in. wide, 18 in. deep. (Fits into standard 19-inch relay rack.)

Other Features. Preset digital dividers expand gate time of associated counter by any factor from 1 to 99.

Built-in mechanical analog computer calculates harmonic number of all harmonics from the 5th to the 100th.

OPERATION

2.1 INSTALLATION

Both the transfer oscillator and the frequency counter may be mounted in a standard 19-inch relay rack. After mounting, make the following interconnections, using the cables provided.

1) Using a coaxial cable, connect the FREQ OUT jack on the transfer oscillator to the A INPUT jack on the Model 7360J or to the E INPUT jack on the Model 7370. This cable delivers the frequency which the counter will actually count.

2) Connect the TIME jack on the counter to the TIME IN jack on the back of the transfer oscillator. This couples clock pulses to preset dividers in the transfer oscillator.

3) Connect the TIME BASE OUT jack on the transfer oscillator to the B INPUT jack on the counter. This couples "start counting" and "stop counting" pulses from the preset dividers to the counter. The interval separating the pulses will be the clock pulse interval multiplied by the harmonic number to which the preset dividers are set.

4) Connect the power cord on both units to a source of AC power, (117 v. ±10%, 50 to 60 cps).

2.2 HOW TO SELECT THE PROPER METHOD OF OPERATION

The method to be employed depends upon the type of input signal and the frequency range in which it lies.

DC to 2 mc.

Use frequency counter alone. See the instruction manual on the counter for directions.

2 mc to Upper Frequency Limit of Counter.

Use frequency counter alone unless signal is frequency-modulated or pulsed RF. In this case, use transfer oscillator as described in next paragraph.

Upper Frequency Limit of Counter to 12,000 mc.

Use transfer oscillator. Select the appropriate fundamental frequency range and follow the procedure for continuous, fixed-frequency signals outlined in section 2.3. If signal is frequency-modulated, modify the procedure as noted in section 2.4. If signal is pulsed RF, modify as noted in section 2.5. Proper fundamental ranges are as follows:

Freq. of Signal to be Measured	Fundamental Range
2 to 7.5 mc (use 2nd, 4th, or 5th harmonic of signal)	7.5 to 15 mc
7.5 to 75 mc	7.5 to 15 mc
75 to 12,000 mc	75 to 150 mc

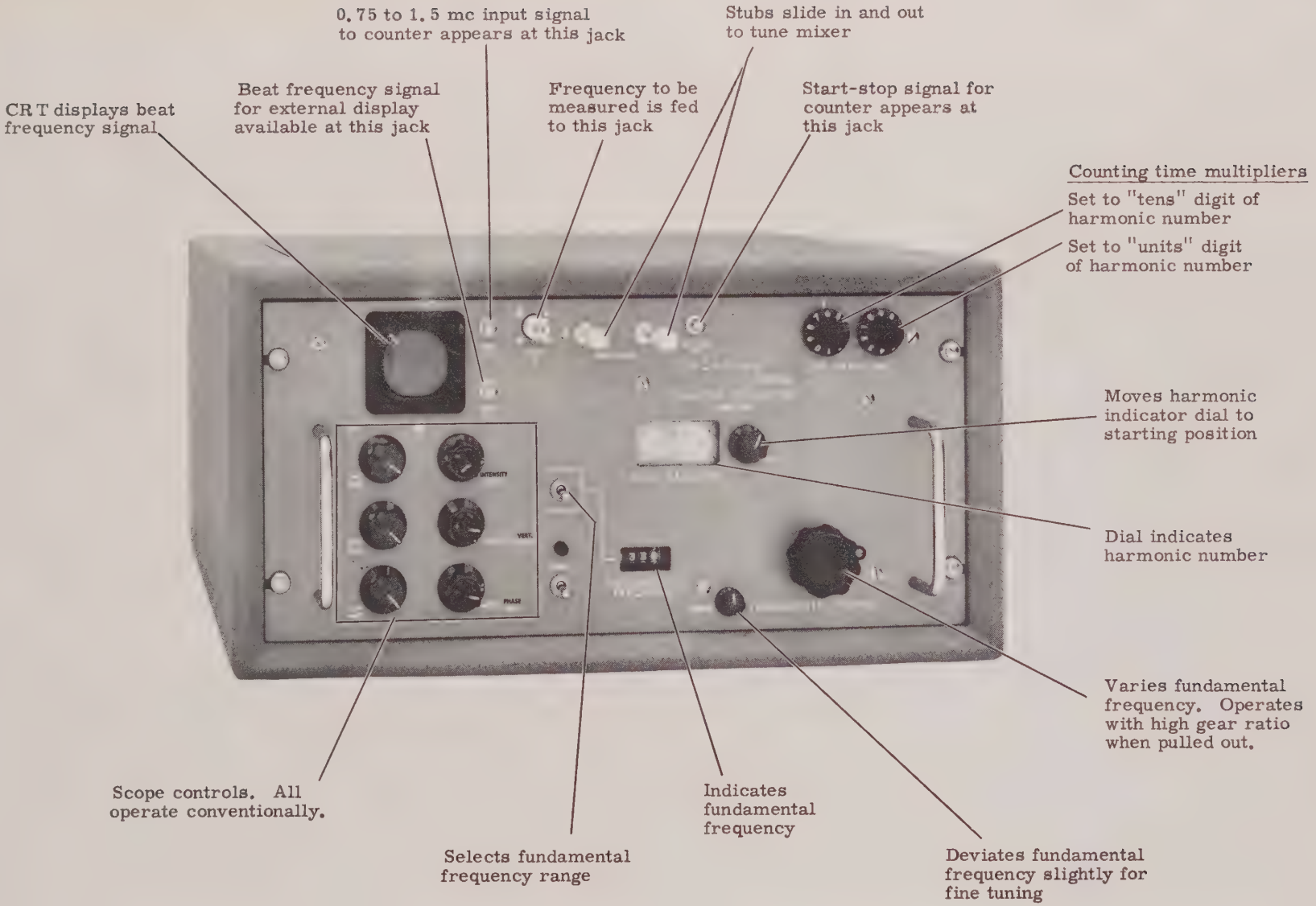

0.75 to 1.5 mc input signal to counter appears at this jack
Stubs slide in and out to tune mixer
CRT displays beat frequency signal
Beat frequency signal for external display available at this jack
Frequency to be measured is fed to this jack
Start-stop signal for counter appears at this jack
Counting time multipliers
Set to "tens" digit of harmonic number
Set to "units" digit of harmonic number
Moves harmonic indicator dial to starting position
Dial indicates harmonic number
Varies fundamental frequency. Operates with high gear ratio when pulled out.
Scope controls. All operate conventionally.
Selects fundamental frequency range
Indicates fundamental frequency
Deviates fundamental frequency slightly for fine tuning

FIGURE 2. FRONT PANEL OF TRANSFER OSCILLATOR

2.3 STEP-BY-STEP PROCEDURE FOR MEASURING CONTINUOUS, FIXED-FREQUENCY SIGNALS

The detailed instructions which follow are intended for an operator totally unfamiliar with the equipment. Once a technician knows the procedure, he can usually make a measurement in less time than it takes to read the directions.

2.3.1 Applying Power and Adjusting the Counter.

1) Apply power to the transfer oscillator and the counter, using the POWER switches on the front panel of each.

2) Adjust the counter controls as follows:

   a) Set FUNCTION switch at A/B or E/B.

   b) Flip both SLOPE switches to "-" (minus).

   c) Set all ATTEN(uation) controls at "1" on the "AC" side.

   d) Rotate the FUNDAMENTAL FREQUENCY dial on the transfer oscillator to 100.0 mc.

   e) Set TIME-SECONDS switch at "10^{-1}".

   f) Turn the SET HARMONIC switches on the transfer oscillator to "10"; that is, left-hand switch at "1", right-hand switch at "0".

   g) In the case of the Model 7360J, set "A" TRIGGER VOLTAGE control midway between limits.

   h) Turn the DISPLAY control fully counterclockwise.

   i) Rotate the "B" TRIGGER VOLTAGE control very slowly back and forth between limits. Notice that at some (if not all) positions, the instrument will count for one second, display the count briefly, then return to zero and start counting again. Adjust the DISPLAY control so that the count will be displayed for a convenient length of time. Any count indication between "0999000" and "1001000" is correct. Set the TRIGGER VOLTAGE control to the midpoint of the arc over which a correct indication appears.

NOTE

In some cases, with the TRIGGER VOLTAGE control of the B channel set as described, the instrument may count for less than the correct 1-second interval. If this happens, turn the B channel ATTEN(uation) control to "10". If the unit still does not function correctly, return the ATTEN(uation) control to "1" and rotate the TRIGGER VOLTAGE control to either side just enough to get proper counting.

2.3.2 Coupling Input to the Transfer Oscillator.

Couple the frequency to be measured to the SIGNAL IN jack on the transfer oscillator front panel. Required signal amplitude varies with frequency. In general, a 100 mv signal out of 50 ohms is more than adequate. See Figure 3 for approximate sensitivity at all points in the frequency range. Input power should not exceed 100 milliwatts.

2.3.3 Initial Control Positions

1) Set the HORIZ GAIN control so that the sweep covers the entire CRT field.
2) Rotate the HIGH FREQ, HORIZ PHASE and VERT GAIN controls fully clockwise.
3) Rotate the LOW FREQ control counterclockwise, then back clockwise to a stop; but do not turn it so far as to get the switch click at the extreme clockwise position.

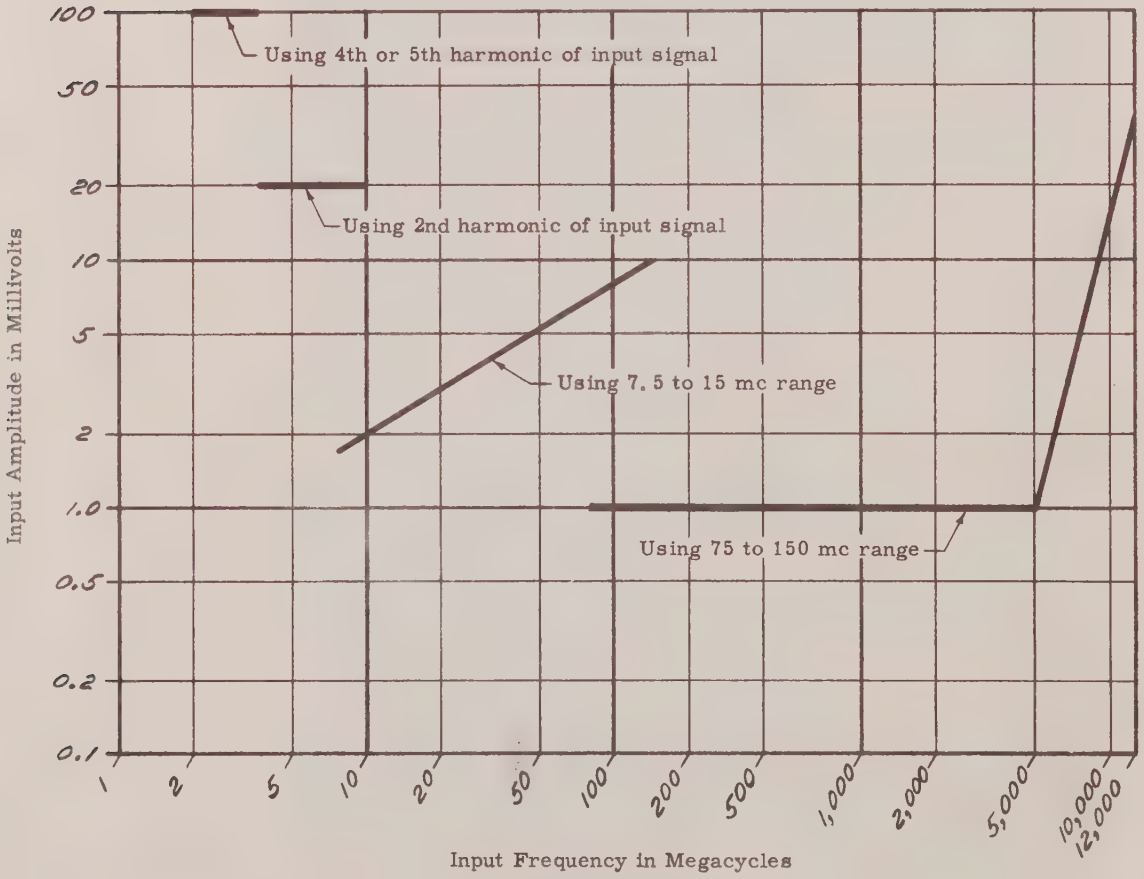


FIGURE 3. INPUT SENSITIVITY OF TRANSFER OSCILLATOR

4) When using the 75 to 150 mc fundamental range, pull tuning stubs about halfway out. Otherwise, remove stubs and add an external shunt resistor to ground for DC return of diodes. (If signal source is DC coupled, the shunt resistor is not needed.)

2.3.4 Locating Zero Beat Points.

The next step is to locate two adjacent fundamental frequencies both of which produce a harmonic whose frequency equals the input frequency. We will call the higher of the two fundamental frequencies "f_H" and the lower "f_L".

1) The FUNDAMENTAL TUNING control has two gear ratios: high when pulled out, low when pushed in. Rotate the FUNDAMENTAL TUNING knob slowly in low gear from one end of its movable range to the other. At one or more points (possibly as many as 10 or 15) a signal will appear on the scope. When using the 75 to 150 mc range, adjust the tuning stubs for maximum amplitude on the scope the first time you see an appreciable signal. Each time you see a signal whose peaks lie outside the vertical field of the scope, reduce the amplitude of the scope display until the entire signal is in view. It is preferable to do this by reducing the amplitude of the signal at the SIGNAL IN jack, but should this be inconvenient simply turn the VERT GAIN control counterclockwise. By following this procedure you will end up with the instrument adjusted so that the strongest signal found will just fill the vertical field of the scope.

2) Rotate FUNDAMENTAL TUNING control as far clockwise as it will go. Rotate the VERNIER control fully clockwise also.

3) Locating higher fundamental, f_H.
Procedure
Rotate TUNING control slowly counterclockwise, thus reducing the fundamental frequency, until an appreciable signal appears on the scope. Adjust TUNING for maximum amplitude, then to near zero beat. (See Figure 4.) Note the FUNDAMENTAL FREQUENCY indication.

Explanation
The signal displayed is a difference frequency created by the input signal beat against a harmonic of fundamental frequency f_H. The approximate value of f_H may be read on the indicator. It is not necessary to obtain an exact zero beat at this point in the procedure.

4) Push in and rotate the ZERO control knob counterclockwise as far as it will go.

5) Locating lower fundamental, f_L.
Procedure
Be very careful not to nudge the FUNDAMENTAL TUNING knob clockwise at this point, instead, rotate it farther counterclockwise, thus reducing the fundamental frequency further, until another appreciable signal appears on the scope. The amplitude of this signal should be comparable to that observed when locating the higher fundamental. If this signal has more than four times the amplitude of the first signal observed, the first signal was a spurious response; in which case, return to step 3 and repeat the procedure. If, on the other hand, this signal has less than 1/4 the amplitude of the first signal, it is a spurious response. In this case, continue to rotate the knob counterclockwise until a suitably large signal appears. First, tune for maximum amplitude, then tune carefully to as near zero beat as possible. If, as zero beat is approached, high frequency noise obscures the low frequency display, turn the HIGH FREQ control counterclockwise to attenuate noise. See Figure 4 for typical scope displays near zero beat. With the LOW FREQ control set as directed in step 3 of section 2.3.3, no frequencies below

1000 cps will appear on the scope. Most input signals will have at least this much frequency wobble, so that it will be unnecessary to see frequencies lower than this in order to reach the best zero beat possible. When dealing with an extraordinarily stable signal, twist the LOW FREQ control clockwise until a switch click is heard. This extends the low frequency response of the scope to 100 cps. Then, adjust the fundamental frequency to a precise zero beat using the VERNIER control.

Explanation.
The signal appearing on the scope is a difference frequency created by a harmonic of f_L beat against the input signal. At zero beat the harmonic equals the input frequency. The FREQUENCY dial indicates the approximate value of f_L. The distance traveled by the harmonic computer as the fundamental was lowered from f_H to f_L enters one term into the harmonic calculator.

2.3.5 Identifying Harmonics and Completing the Measurement.

1) First find the harmonic number of f_L. For the first revolution of the READ HARMONIC dial, the harmonic number is indicated on the left-hand scale of the dial. After the first revolution, the harmonc number is indicated on the right-hand scale. If the READ HARMONIC indicator has moved steadily as the fundamental was lowered from the higher to the lower frequency, the harmonic number of f_L may be read directly from the indicator. (See Figure 5 for directions.) On the other hand, if the indicator stops moving before the lower fundamental is reached, the operator must calculate the harmonic number of f_L, using the following formula:

$$\text{Harmonic number of } f_L = \frac{f_L}{f_H - f_L} + 1$$

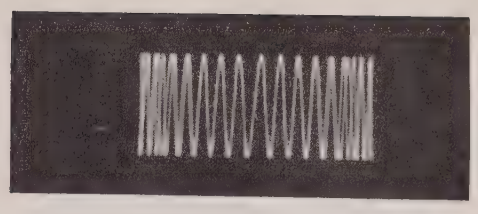
This calculation will be necessary only when dealing with harmonics below the 4th, so the values of f_H and f_L as read from the FUNDAMENTAL FREQUENCY indicator are sufficiently accurate to determine the harmonic number, which will be an integer less than 4.

2) Position the SET HARMONIC switches at the harmonic number of f_L. For example, if the READ HARMONIC indicator read "28", the operator would turn the left-hand switch to "2" and the right-hand switch to "8".

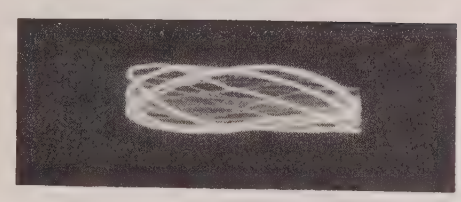
3) Read the frequency indication on the counter front panel. For most measurements it is convenient to place the FUNCTION switch at A/B or E/B and to take initial readings with the TIME switch at 10^{-2}. Final, more precise readings can be made with the TIME switch at 10^{-1} or 1. (Note: The TIME switch on the counter should never be set for an interval smaller tha 10^{-3} seconds.)

2.3.6 Verifying the Results. Check the frequency reading by returning the FUNDAMENTAL FREQUENCY indication to the higher fundamental, f_H. This time, adjust the frequency as closely as possible to zero beat. Then position the SET HARMONIC switches at the harmonic number of f_H; that is, reduce the number selected by one. With allowance for accuracy limitations, the counter reading should be the same as the earlier one. If this reading is higher than the first one, the true harmonic number must be lower than that calculated; therefore, try the next lower harmonc number at both zero beats. The reverse holds true if the check produces a lower reading. When both readings are the same, the harmonic numbers are certain to be correct.

A. Display near enough zero beat to produce a visible difference frequency.



B. Display when closer to zero beat than in A above. Individual cycles of difference frequency (now approximately 1000cps) are visible.



C. Display at the best zero beat possible. Input frequency is not absolutely stable; consequently scope shows a part of one cycle of difference frequency as the input frequency wobbles to each side of zero beat. A perfectly stable signal would produce a straight horizontal line at zero beat.

FIGURE 4. SCOPE DISPLAYS NEAR ZERO BEAT WHEN MEASURING A FIXED-FREQUENCY SIGNAL

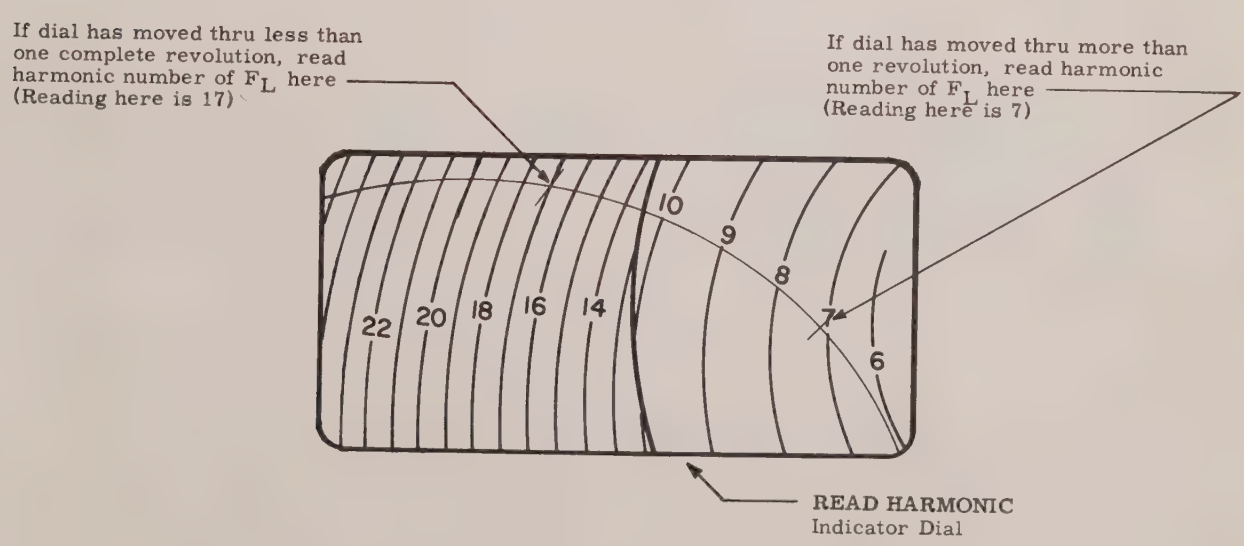


FIGURE 5. HOW TO READ HARMONIC NUMBER

2.4 HOW TO MEASURE FM SIGNALS

This instrument will measure signals which are frequency modulated at 60 or 120 cps. The method of measurement is the same as that given for fixed-frequency signals except that the built-in scope is swept by a signal of the modulating frequency. For modulating frequencies other than 60 or 120 cps, an optional feature is available which provides for an external sweep input.

The scope displays near zero beat will resemble those shown in Figure 6. The input frequency will pass through zero beat twice during each sweep cycle. These points appear as regions of minimum frequency on the face of the scope. With the horizontal sweep phase adjusted properly, the two zero-beat points will be coincident. If the LOW FREQ control is turned full counterclockwise until a switch clicks, frequencies as low as 100 cps will appear on the scope, permitting the operator to locate the zero-beat point with maximum precision.

It is possible to measure the approximate frequency deviation of a signal by varying the FUNDAMENTAL FREQUENCY control until the zero-beat point appears first at one end, then at the other end of the sweep span. The frequency deviation will then be the difference between the indicated frequency at each extreme. The center frequency will be that indicated with the zero-beat point at the middle of the sweep.

2.5 HOW TO MEASURE PULSED RF SIGNALS

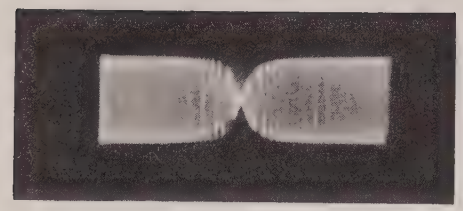
The instrument will measure the carrier frequency of pulses as narrow as one microsecond. With the following exceptions, the procedure is the same as that used for measuring continuous signals:

1) The beat frequency must be displayed on a separate oscilloscope which is synchronized to begin each sweep when, or slightly before, each pulse occurs. To do this, couple the VIDEO OUT jack to the scope input and trigger the scope with a signal synchronized with the occurrence of pulses.
2) Turn HIGH FREQ control fully clockwise and LOW FREQ control fully counterclockwise to obtain broadest possible video frequency range.
3) Near zero beat the scope pattern will be similar to those shown in Figure 7. Adjust the frequency control for a group of parallel lines as nearly horizontal as possible.

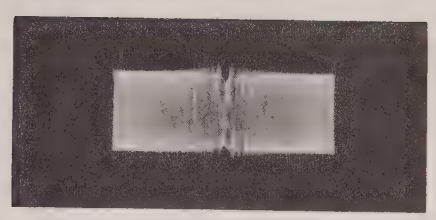
2.6 ACCURACY

The possible error of any measurement depends upon four factors:

1) The ± one count error contributed by the gating action in the counter.
2) The deviation of the harmonic frequency from a precise zero beat with the input signal.
3) The stability of the fundamental frequency.
4) Accuracy of the clock signal from the counter.



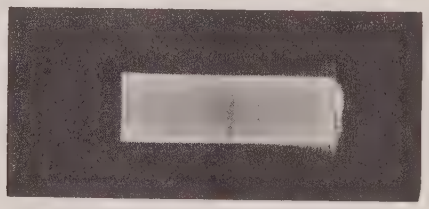
Low Freq cut-off: 1000cps



Low Freq cut-off: 100cps

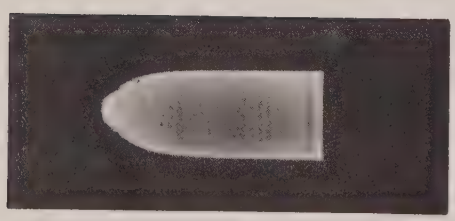
A. Scope display with zero beat at center frequency.

Low Freq cut-off: 1000cps

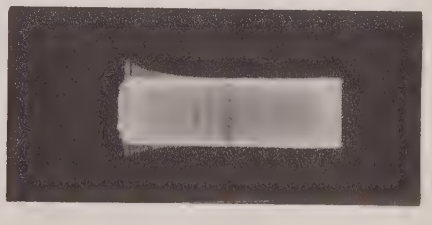


Low Freq cut-off: 100cps

B. Scope display with zero beat at one extreme of frequency deviation.



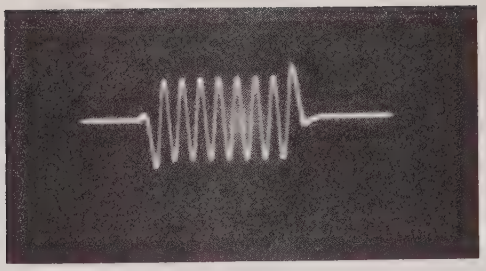
Low Freq cut-off: 1000cps



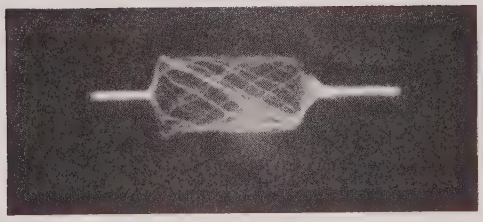
Low Freq cut-off: 100cps

C. Scope display with zero beat at opposite exterme of frequency deviation

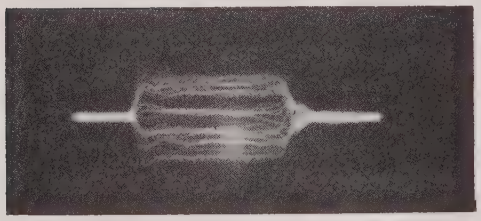
FIGURE 6. SCOPE DISPLAYS NEAR ZERO BEAT WHEN MEASURING AN FM SIGNAL. CENTER FREQUENCY OF INPUT SIGNAL PRODUCING THESE DISPLAYS IS ABOUT 4000MC; FREQUENCY DEVIATION, ABOUT 30KC.



A. Display when near enough to zero beat to see how many cycles of the difference frequency signal occur during the period of one pulse.



B. Display when closer to zero beat than A, above.



Display when as near zero beat as possible. At perfect zero beat the display would be a group of straight horizontal lines. Irregularities in this display are caused by an input signal wh ich varies slightly in frequency, as nearly all signals do.

FIGURE 7. SCOPE DISPLAYS NEAR ZERO BEAT WHEN MEASURING A PULSED R-F SIGNAL

To take an ideal example, suppose the input were a perfectly fixed frequency of 4000 mc. In this case, the fundamental frequency would be adjusted to 100 mc and the 40th harmonic brought to zero beat with the input frequency. The counter would count cycles of a 1 mc signal over a period of 4 seconds (0.1 secs times 40). The possible error of this measurement is the sum of three errors:

1) ±1000 cps due to possible gating error of ±1 count. With the counter TIME switch at 10^{-1} each count represents 1000 cycles.

2) ±100 cps due to possible inaccuracy in zero beat setting. Beat frequencies below 100 cps are not observable on the scope.

3) ±1 part in 10^7 stability of fundamental frequency over a 10-second period.

4) ±3 parts in 10^7 possible error of clock signal generated by counter.

Summing these possible errors, we get 1100 cps (3 parts in 10^7) plus 1 part in 10^7 plus 3 parts in 10^7 which is approximately 7 parts in 10^7. If we try to decrease the counting error by increasing the gate time from 4 to 40 seconds, the improvement is offset by an increase in frequency drift of the fundamental over the longer period.

Additonal error is introduced when the input signal varies in frequency. If it varies slowly, a skillful operator can track the signal by varying the fundamental frequency to maintain an approximate zero beat at all times during the 4-second counting period. In this case, the reading will be an average frequency over the 4-second period. If the input frequency wobbles back and forth so rapidly that it cannot be tracked, the reading will simply be the frequency at some point in the frequency swing.

2.7 SPECIAL NOTES ON OPERATION

When the transfer oscillator is used for signals in the 2 to 7.5 megacycle range, the 2nd, 4th or 5th harmonic of the unknown signal is actually measured. In this case, the SET HARMONIC switches should be set to the reciprocal of the harmonic number used (i.e., 5, 25, or 2). This will automatically multiply the counting period by the proper factor so that the counter will display the correct frequency.

Signals barely above specified sensitivity can be measured, but zero-beat points are difficult to locate if the frequency of the signal is completely unknown. Therefore, unless you know the approximate frequency, it is recommended that input signals have five times the minimal amplitude shown on the sensitivity curve of Figure 3.

If the approximate frequency is known, the search for zero beat points can be simplified by substituting the following procedure for the scanning procedure described in section 2.3.4.

1) Adjust the fundamental frequency to near the top of the selected range.

2) While watching the counter indication, change the SET HARMONIC switch setting until the counter reading is near the frequency being measured.

3) Adjust the fundamental until the counter reads the approximate frequency.

4) Search the narrow band in which the input frequency lies by slowly varying the fundamental a little in either direction. If operating in the 75 to 150 mc fundamental range, adjust the tuning stubs periodically during this search until a beat frequency is located, then tune stubs for maximum amplitude.

When using the fundamental frequency range of 75 to 150 mc, the MIXER TUNING stubs may produce peak scope amplitude in more than one position; however, the scope display will contain obscuring noise at the more extended positions. In these cases, search for the least extended position at which a satisfactory amplitude peak occurs.

2.8 OPERATING CONTROLS, CONNECTORS AND INDICATORS

POWER switch

Applies line power to transfer oscillator.

Two-inch oscilloscope

Displays difference frequency resulting from input signal beat against a harmonic

VERT GAIN control

Increases vertical gain of scope when turned clockwise.

HIGH FREQ control

Decreases high frequency response of scope when turned counterclockwise. Low frequency cutoff (6db down) may be varied from 250 kc (extreme counterclockwise position) to 1000 cps (turned clockwise to a stop) to 100 cps (twisted clockwise until a switch clicks).

INTENSITY & FOCUS controls

Control intensity of trace on scope and focus of cathode ray.

VERT & HORIZ CENTERING controls

Control position of trace on face of scope.

HORIZ GAIN control

Expands trace horizontally when turned clockwise.

HORIZ PHASE control

Varies phase of 60 cps internal horizontal sweep signal.

VIDEO OUT jack

The beat frequency signal is available here for an external scope display.

FUNDAMENTAL TUNING control

Adjusts fundamental frequency over selected range.

VERNIER control

Varies fundamental frequency slightly.

FUNDAMENTAL FREQUENCY indicator

Indicates value of fundamental frequency within selected range.

READ HARMONIC indicator

Used to compute harmonic number. (See Figure 5 and section 2.3.5.)

ZERO HARMONIC control

Used to move harmonic computer to starting position before computation.

SET HARMONIC switches

Counting period of counter will be expanded by the factor set on these switches. Switches should be set to number of whatever harmonic is brought to zero beat with input signal.

SIGNAL IN jack

Couple signal whose frequency is to be measured to this jack. (See paragraph 2.3.2)

MIXER TUNING stubs

These are sliding-short tuning stubs connected in parallel with the SIGNAL IN jack.

FREQ OUT jack

Signal which the counter measures appears at this jack. The frequency here is 0.75 to 1.5 mc. (See step 1 under paragraph 2.1)

TIME BASE OUT jack

"Start counting" and "stop counting" signals for counter appear at this jack. (See step 3 under paragraph 2.1)

117VAC line power connector

Mounted on rear panel. This is the line power input connector. (See step 5 under paragraph 2.1)

TIME BASE INPUT jack

Mounted on rear panel. Clock pulses from the counter should be coupled to this jack. (See step 2 under paragraph 2.1)

CIRCUIT DESCRIPTION

3.1 OSCILLATOR, BINARY AND MULTIPLIER CHAIN

The three fundamental frequencies are developed by an oscillator driving a chain of frequency multipliers and a divider. The oscillator (V801) generates a signal whose frequency may be varied from 1.5 to 3 mc. This signal drives the first frequency multiplier (V302) which multiplies the oscillator frequency by 5, producing the intermediate fundamental frequency which varies from 7.5 to 15 mc at the same time that the oscillator is varied over its frequency range. The output of V302 drives two more frequency multipliers which, taken together, multiply by 10, thus producing the highest fundamental frequency which is variable over the range of 75 to 150 mc. The oscillator and the frequency multipliers are gang-tuned.

The oscillator signal is also fed through a pulse shaper (V403) to a binary (V404) which divides the oscillator frequency by two. This provides the 0.75 to 1.5 mc base frequency to the counter. Notice that the two fundamental frequencies and the base frequency always differ by factors of ten. The lower fundamental (5 times the oscillator frequency) is 10 times the base frequency (1/2 the oscillator frequency), and the higher fundamental is 10 times the lower one. This relationship makes it possible to monitor both fundamental frequencies by feeding only the base frequency to the counter.

3.2 MIXER AND BEAT FREQUENCY INDICATOR

The range switch selects one of the fundamental frequencies generated. This signal drives a crystal diode which generates harmonics up to and above the 80th. These harmonics are then mixed with an input signal in another crystal diode, producing a multitude of difference frequencies. The output of the diode is amplified by the first video amplifier (V201), then fed through a low pass filter which blocks all frequencies above 1.5 mc. This removes all frequencies except the comparatively low beat frequency produced by the input frequency and a harmonic nearly equal to the input frequency. The beat signal is amplified by several video stages (V202 thru V204) and then applied to the vertical deflection plates of a small CRT, where it may be observed. The beat signal is also coupled to the VIDEO OUT jack.

The horizontal sweep for the CRT is a 60 cps sinusoidal signal, derived from the power supply transformer and amplified by V205. Both the amplitude and phase of this signal are adjustable.

3.3 TIME BASE MULTIPLIER

The electronic counter ordinarily counts for 0.1, 1.0 or 10 seconds, the counting period being determined by the interval between the clock pulses it generates. Operated in this way, it would register one of the fundamental frequencies of the transfer oscillator. However, when used in this system, the counter delivers clock pulses to a circuit in the transfer oscillator which in effect multiplies the clock pulse interval by a predetermined factor. This factor is the number of the harmonic generated which zero beats with the unknown frequency. The multiplier circuit (called The Time Base Multiplier) consists of two glow-transfer decade counters (V406, V407) connected in cascade.

Incoming clock pulses are amplified and shaped by V401A and V401B-V402A respectively, and counted by V406 and V407. An output pulse is then produced at any preset number of counts from 1 to 99. For example, assume that the 33rd harmonic produced a zero beat with the unknown frequency and the SET HARMONIC switches were therefore set at 33. Since V406 is always initially set to 1, a coincidence signal at the count of 32 opens the diode gate CR406. This allows the 33rd pulse at the cathode of V402A to pass through CR406 and reach the external counter to start a frequency counting period. Pulse number 33 also triggers the one-shot multivibrator, V403, which generates a reset signal for V406 and V407. As soon as V406 and V407 are reset, they close gate CR406 and begin counting clock pulses again. Thirty-three clock pulses later, another pulse reaches the counter to terminate the counting period. In this way, the counting period is multiplied by 33 so that the counter will indicate a number 33 times the fundamental frequency or, in other words, the frequency of the 33rd harmonic.

3.4 Harmonic Calculator

To use the harmonic calculator it is necessary to locate two adjacent fundamental frequencies each of which produce a harmonic equal to the input frequency. If we call the two fundamentals f_H (higher fundamental) and f_L (lower fundamental) the harmonic calculator solves the equation:

$$n = \frac{f_L}{\triangle f} + 1 \qquad \text{where} \quad \triangle f = f_H - f_L$$

n = harmonic number of f_L

The rotating dial of the calculator is turned manually to the end of the scale at a time when the transfer oscillator is tuned to f_H. Then the dial is allowed to rotate, geared to the FUNDAMENTAL TUNING control while the control is moved to f_L. If the dial has rotated thru less than one complete revolution, the harmonic number is indicated by the crosshairs at the left-hand portion of the scale. If, however, the dial has moved through more than one revolution, the harmonic number is indicated by the crosshairs at the right-hand portion of the scale.

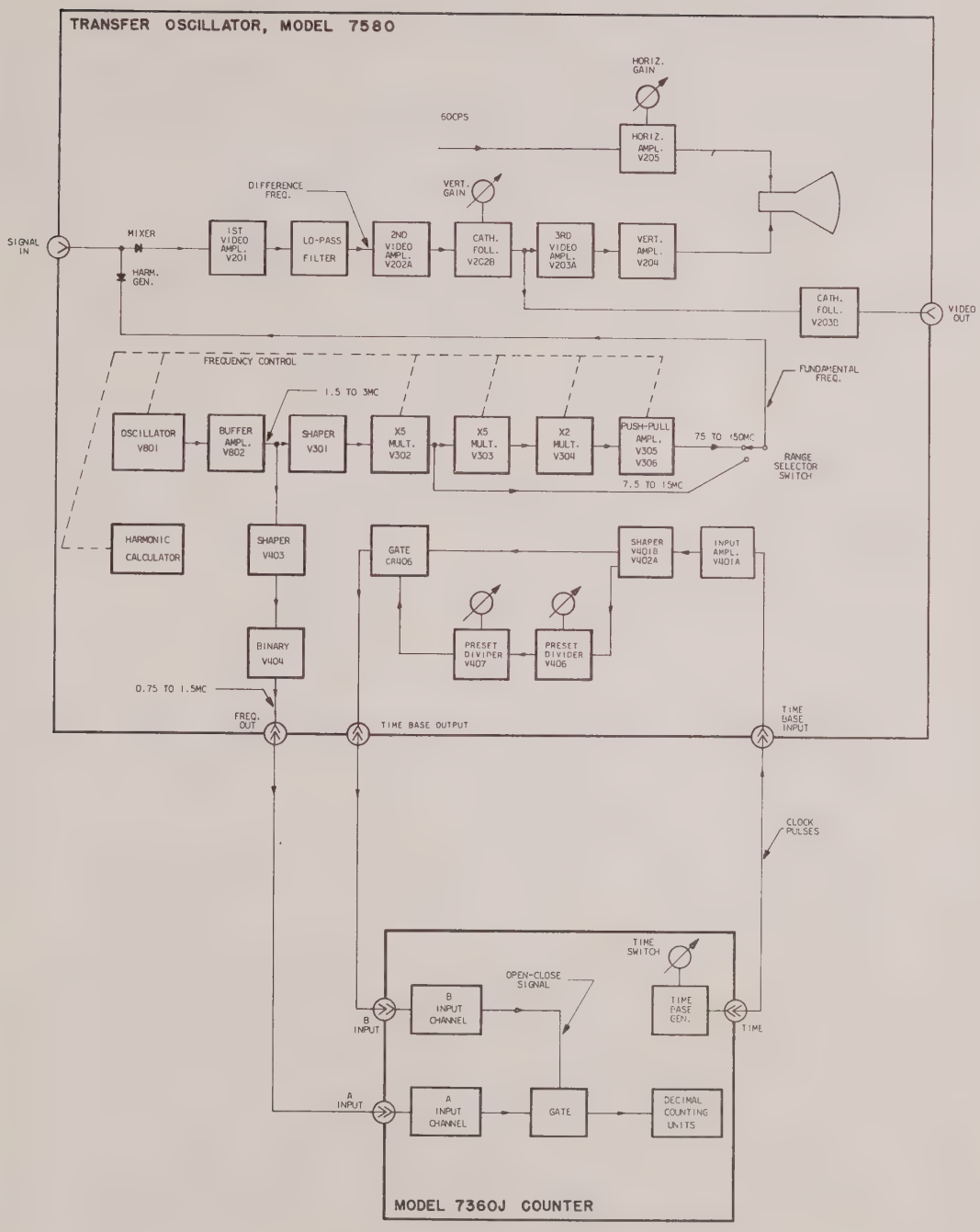


FIGURE 8. BLOCK DIAGRAM OF MODEL 7580 TRANSFER OSCILLATOR

4.1 ADJUSTING THE MULTIPLIER CHAIN

Ordinarily, the frequency multipliers will require adjustment only when tubes have been replaced. At that time it may be necessary to adjust the trimmer capacitors in the parallel tuned circuits of each stage to compensate for stray tube capacitance. All trimmer capacitors and test points located on the top of the multiplier chassis and identified by a detail number stamped on the chassis. See "Schematic Diagram, Oscillator and Multiplier Chain" for a diagram of the circuit being adjusted. When measuring a DC voltage use a VTVM with an input resistance of 10 megohms or more. Proceed as follows:

1) Adjust the fundamental frequency to about 150 mc.
2) Adjust capacitors C308 and C315 for a maximum DC voltage between test point E302 and ground.
3) Adjust C317 and C321 for maximum DC voltage between test point E303 and ground.
4) Disconnect P303 from J303 on chassis, couple a 50-ohm load to J303 and adjust C325 and C338 for a maximum RF voltage across the 50-ohm load.
5) Make a final adjustment of all six trimming capacitors for maximum AC voltage across the 50-ohm load.
6) Remove 50-ohm load and reconnect P303 to J303.

4.2 ADJUSTING THE POSITIVE DC SUPPLY

Adjust the +225 v. ADJUST control (located and identified on top of the proper supply chassis) for +225 volts ±2 percent with respect to ground at pin 6 of V103.

MODIFICATION H

In this modification, the instrument uses a power transformer wired so that it can be energized from a 220 volt 50-400 cps AC source. If necessary, this transformer (T101) can be rewired for operation from a 117 volt AC line as shown in Figure H.

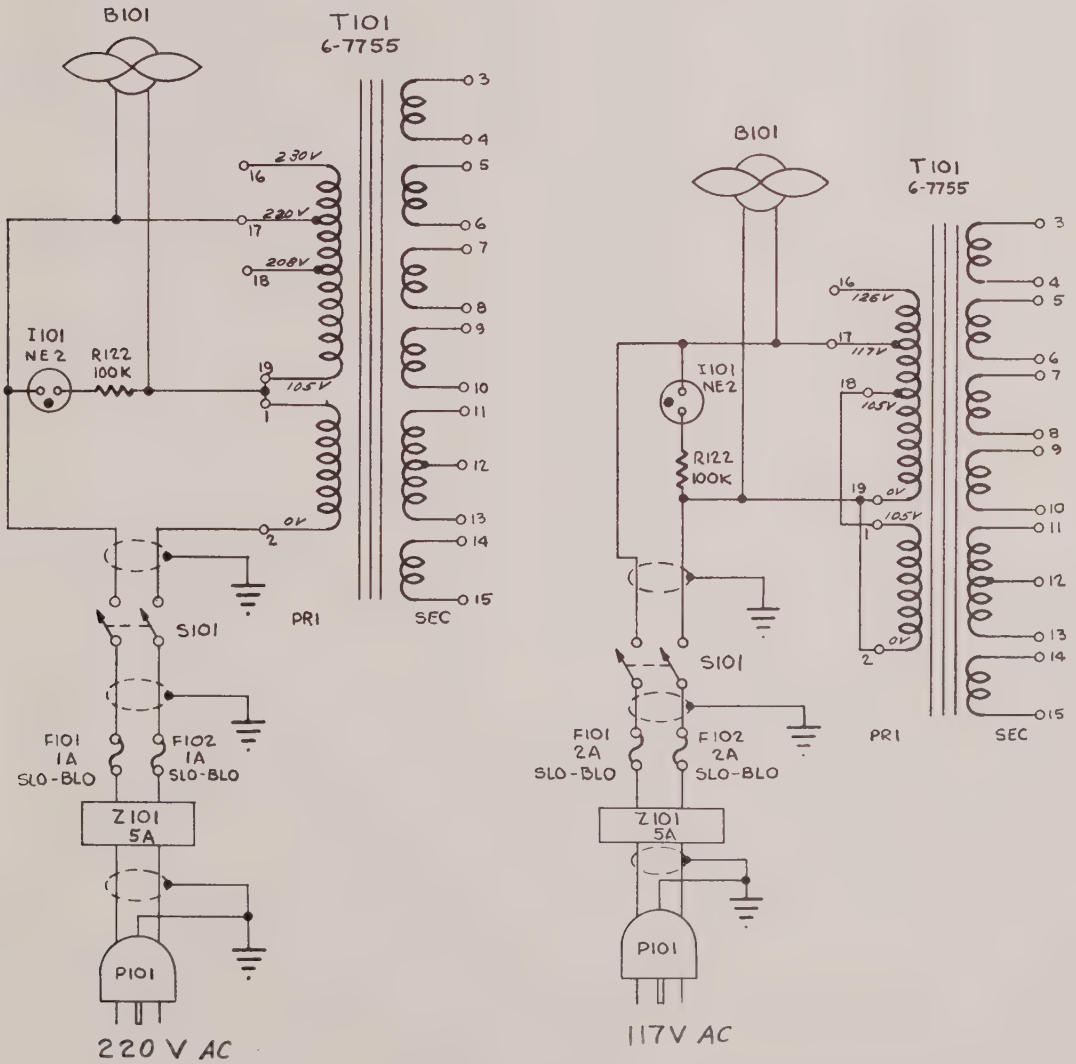


FIG. H. This diagram shows how the power transformer of Modification H is wired for 220 volt and 117 volt AC operation.

MODIFICATION R

In this modification, the instrument is supplied without a cabinet but with a cover on top of the chassis. This cover enables the cooling system to function properly when the unit is installed and operated in a standard relay rack.

Chassis and mounting dimensions are as shown in Figure R.

EXTERNAL SWEEP MODIFICATION

In this modification, a coaxial connector (J203), coupling capacitor (C235), and toggle switch (S201) have been added to the beat indicator circuit as shown in Figure S. The connector and switch are mounted on the rear panel of the instrument and make it possible to replace the internal CRT sweep with an external signal having these characteristics:

Frequency range:	60 to 15, 000 cps
Amplitude:	2 volts rms per inch

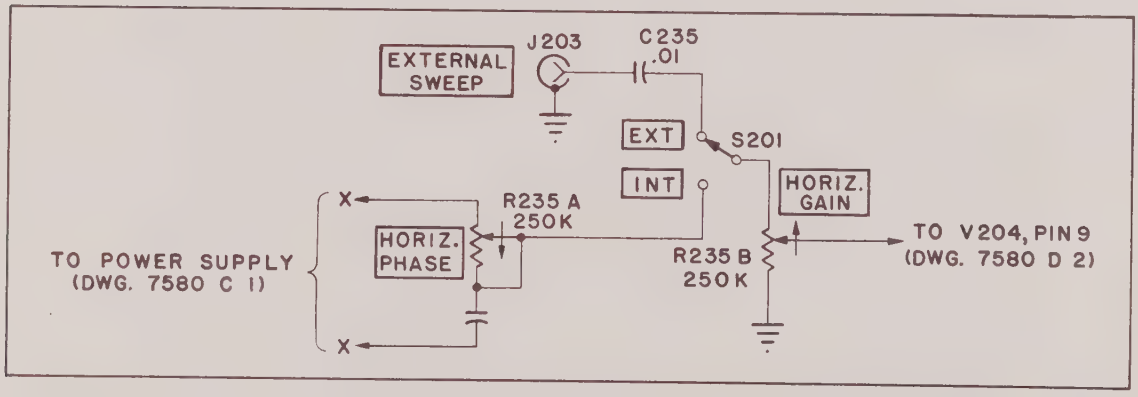


FIG. S. Changes in the beat indicator circuit made under the external sweep modification.

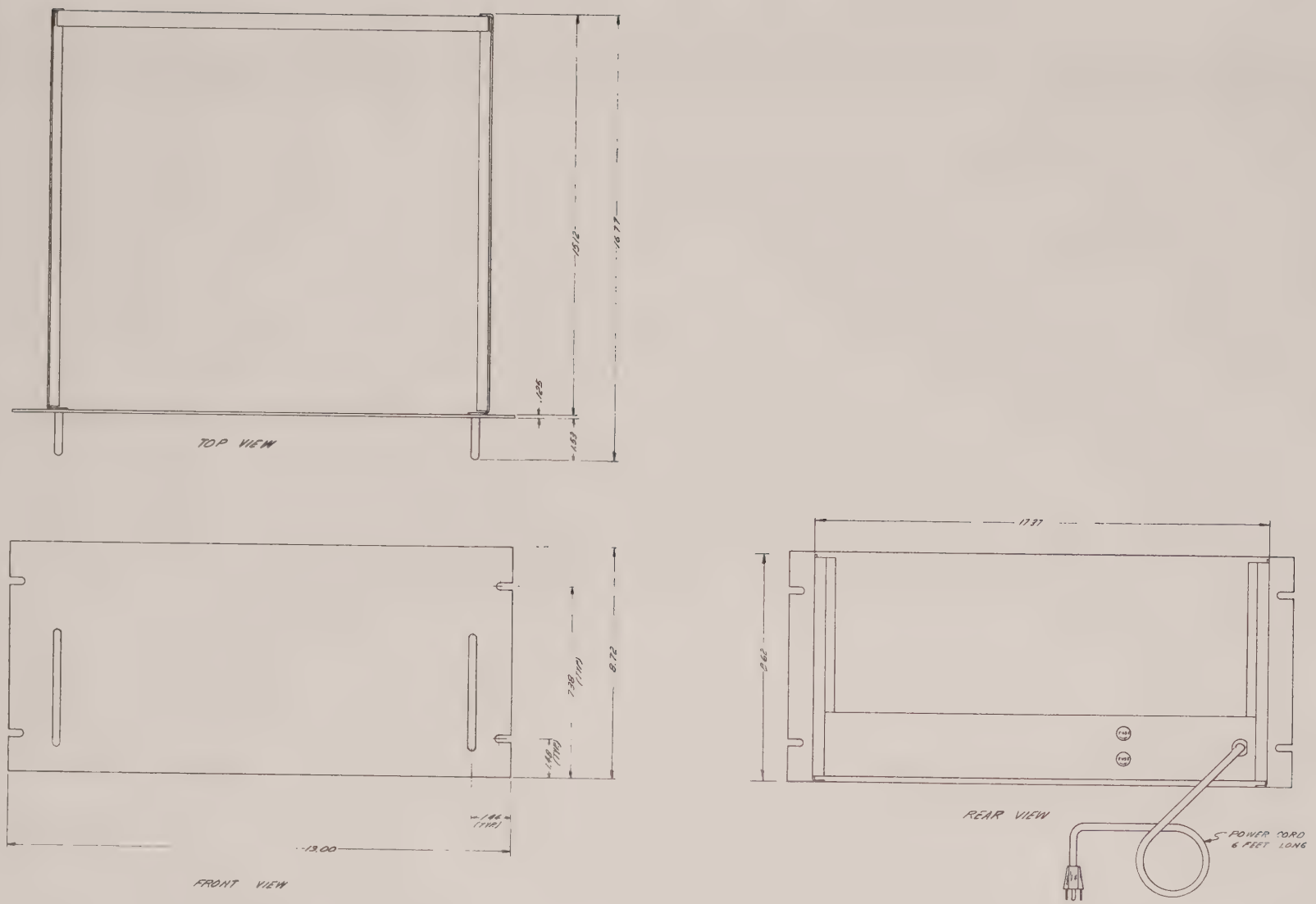
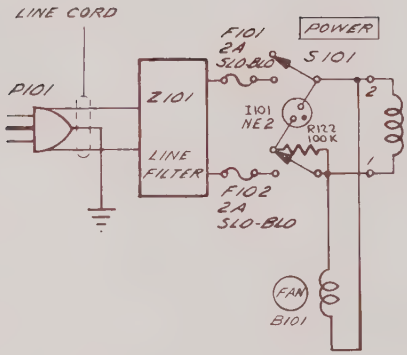
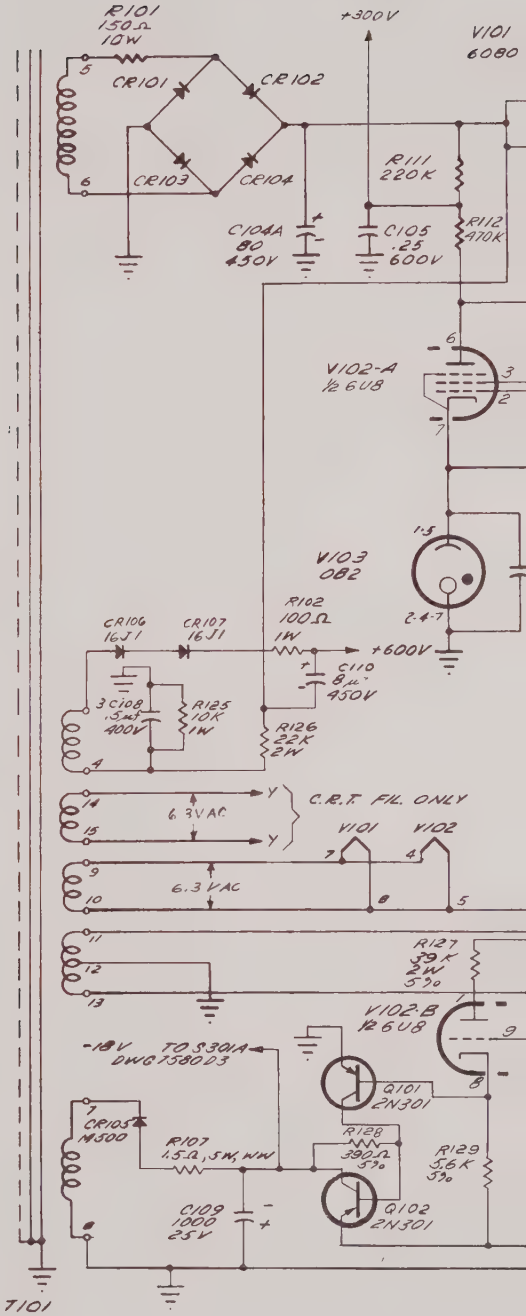


FIG. R. Rack mounting and chassis dimensions of instrument supplied with Modification R.

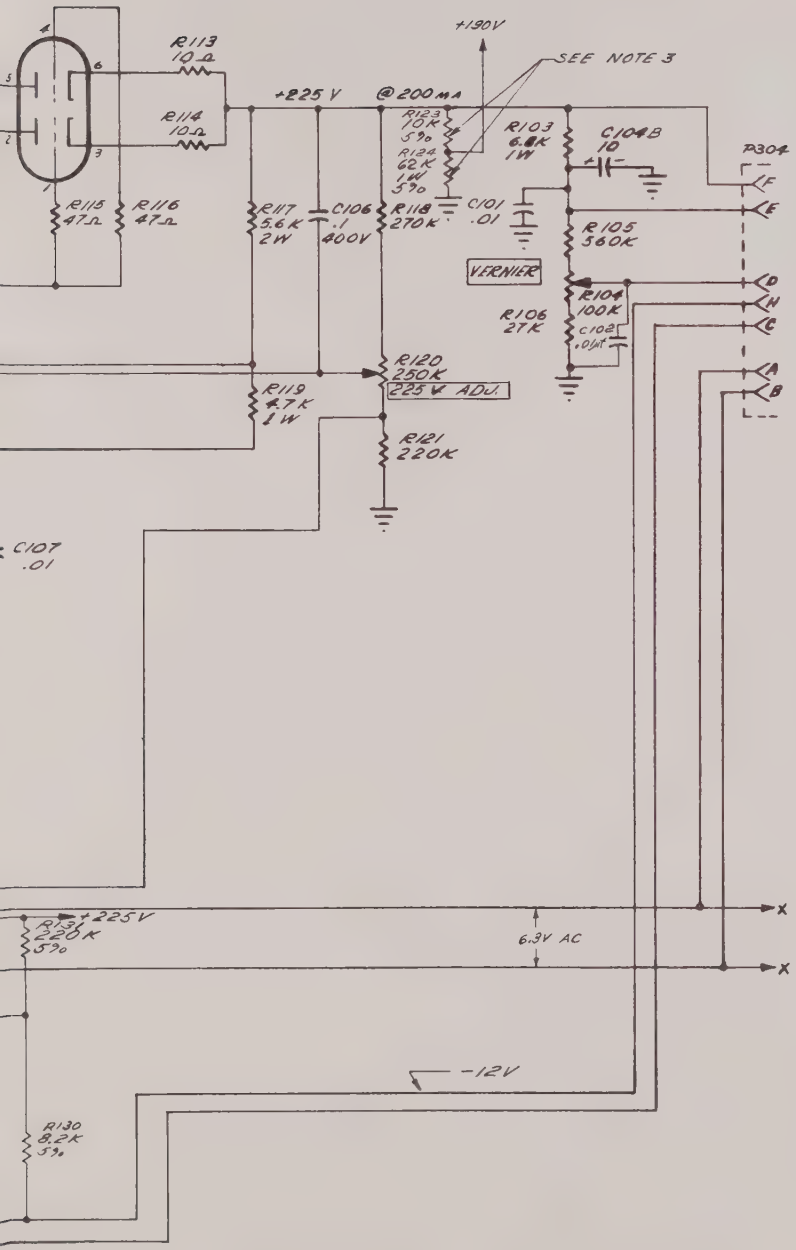


NOTES:

1) RESISTORS:
   WATTAGE IS 1/2 W, UNLESS OTHERWISE NOTED.
   TOLERANCE IS 10 %, UNLESS OTHERWISE NOTED.
2) CAPACITORS:
   CAPACITY VALUE IN μ F.
3) R123 & R124 MAY BE SHUNTED BY RESISTORS SELECTED AT FACTORY.



POWER SUPPLY
SCHEMATIC DIAGRAM



BECKMAN/ BERKELEY DIVISION
DWG. NO. 7580 C 1

PARTS LIST, BEAT FREQUENCY INDICATOR

Refer to Dwg. No. 7580 D 2

NOTE

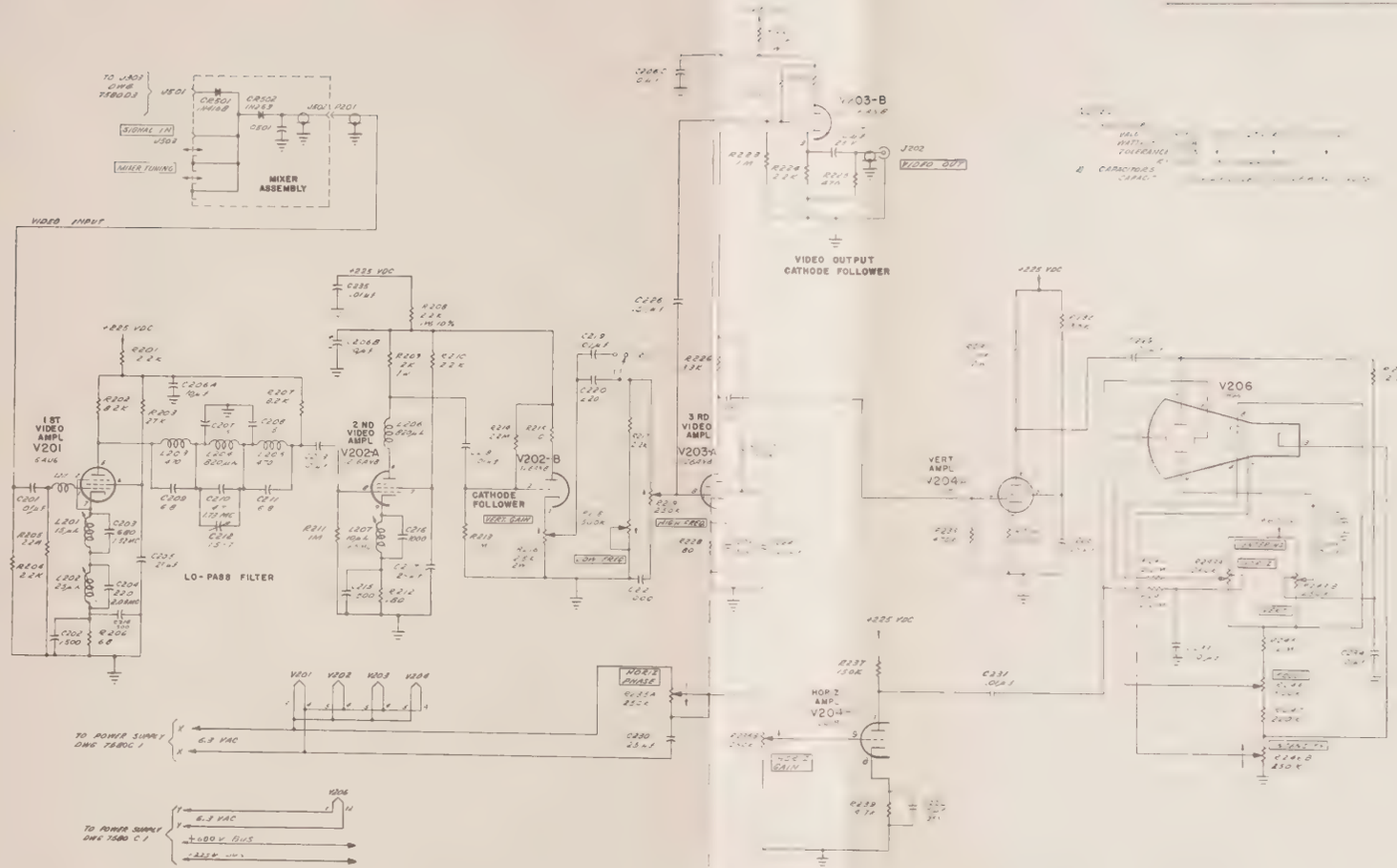
The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

AB	Allen Bradley Company, Milwaukee, Wisconsin
B/B	Beckman/ Berkeley, Richmond, California
CTC	Cambridge Thermionic, Cambridge, Mass.
CTS	Chicago Telephone Supply Company, Elkhart, Indiana
RMC	Radio Materials Company, Chicago, Illinois

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C201	2-3230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C202	2-3610	Capacitor, ceramic, .0015μμf, 600V, 10%	Erie 801-.0015
C203	2-4921	Capacitor, mica, 680μμf, 500V, 5%	Sangamo KR1368
C204	2-3624	Capacitor, mica, 220μμf, 500V, 5%	Sangamo RR1322
C205	2-2760	Capacitor, paper, 0.25μf, 400V, 20%	Sangamo 3304025
C206	2-5748	Capacitor, electrolytic, 10 x 10 x 10μf, 450V	Astron EYT1030
C207	2-3082	Capacitor, ceramic, 15μμf, 600V, 10%	Erie NPO331
C208		Same as C207	
C209	2-3508	Capacitor, ceramic, 6.8μμf, 600V, 10%	Erie GPIK
C210	2-3618	Capacitor, ceramic, 4.7μf, 600V, 10%	Erie GPK-N330
C211		Same as C209	
C212	2-3355	Capacitor, ceramic, 1.5-7μμf, 20%	Erie 503
C213		Same as C201	
C214 & C215		Same as C202	
C216	2-3065	Capacitor, mica, 1000μμf, 500V, 5%	Sangamo KR1210
C217		Same as C205	
C218		Same as C201	
C219	2-4655	Capacitor, ceramic, .01μf, 600V, 10%	RMC JF-.01
C220		Same as C204	
C221	2-5793	Capacitor, ceramic, .001μf, 1000V, 10%	Centralab DD102
C222	2-3244	Capacitor, electrolytic, 10μf, 25V	Sangamo MMT 0210
C223		Same as C202	
C224		Same as C205	
C225		Same as C201	
C226		Same as C222	
C228		Same as C205	
C229		Same as C201	
C230	2-5747	Capacitor, paper, 0.25μf, 200V	Hopkins MPA, 25-200
C231		Same as C201	
C232 thru C247		Same as C201	

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C501		p/o Mixer Assembly	
CR501	8-4982	Diode, 1N416B	Bomac
CR502	8-4983	Diode, 1N263	Philco
J202	17-4985	Connector, coaxial	Automatic Metal UG1094/U
J501	17-7407	Connector, BNC	Automatic Metal RF0174
J502		Same as J501	
J503	17-4986	Connector, coaxial	Amphenol 82-207
L201	3-5284	Inductor, 10-18μh	CTC X2060-4
L202	3-7173	Inductor, 16-30μh	CTC X2060-5
L203	3-6164	Inductor, 500μh	Wilco-1500-15
L204	3-7122	Inductor, 820μh	National Coil SA820-1
L205		Same as L203	
L206		Same as L204	
L207	3-5285	Inductor, 6.5-10.6μh	CTC X2060-3
L211	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
P201	17-6617	Connector, coaxial	Amphenol 31-002
R216	1-3209	Potentiometer, 2.5K, 2W, 10%	AB JU 2521 SD3048
R218	1-7254	Potentiometer, 500K, 1/2W, 20%, W/switch	CTS VF-35
R219	1-0644	Potentiometer, 250K, 2W, 20%	AB JU 2542 SD3048
R235	1-7255	Potentiometer, 2-sec. Front 250K, 1/2W, 20% St'd D taper Rear: 250K, 1/2W, 20% log taper	B/B
R243	1-7256	Potentiometer, 2-sec. 250K ea., 1/2W, 20%	B/B
R246	1-7259	Potentiometer, 500K (front) 250K (rear) 1/4W, 20%	B/B
S201		Switch, SPDT (p/o R218)	B/B
V201	5-0550	Tube, 6AU6	
V202	5-6072	Tube, 6AN8	
V203		Same as V202	
V204	5-2526	Tube, 6U8	
V206	5-4834	CRT, 2BP1	
XV201	4-0464	Socket, 7 pin	Cinch 53B12559
XV202	4-0794	Socket, 9 pin	Elco 283BC
XV203 & XV204		Same as XV202	
XV206	4-7178	Socket, 12 pin	Cinch Jones 3B12



BECKMAN/ BERKELEY DIVISION
DWG. NO. 7580 D 2

PARTS LIST, OSCILLATOR & MULTIPLIER CHAIN

Refer to Dwg. No 7580 D 3

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

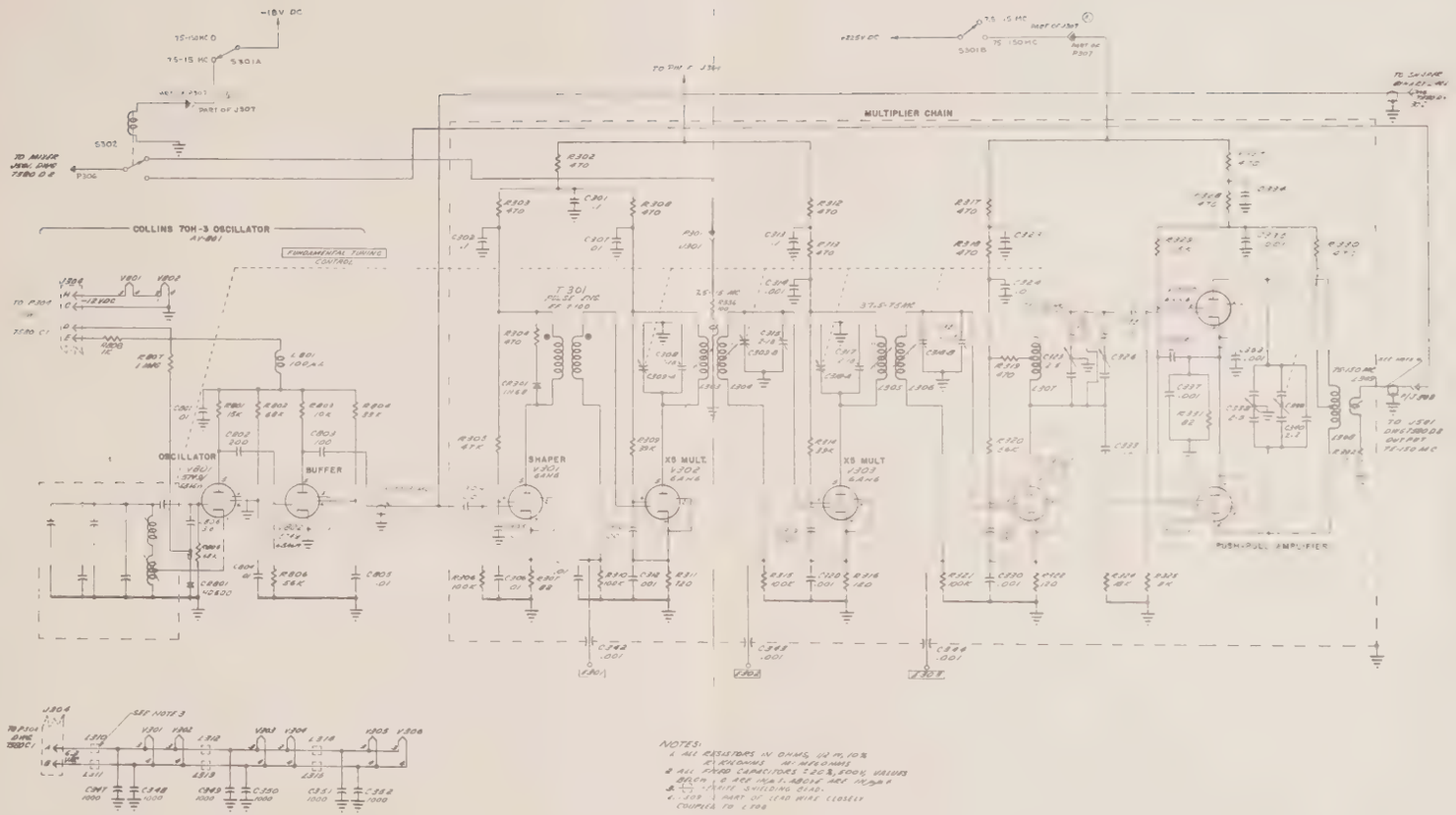
B/B	Beckman, Berkeley, Richmond, California
CH	Cutler-Hammer, Inc., Milwaukee, Wisconsin
CTS	Chicago Telephone Supply Company, Elkhart, Indiana
JFD	JFD Electronics, Inc., Brooklyn, New York

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
AY801	22-4968	Oscillator Assembly	Collins 70H3
C301	2-3085	Capacitor, paper, 0.1μf, 400V, 20%	Sprague 78 P1040455
C302		Same as C301	
C303	2-5244	Capacitor, ceramic, 0.68μμf, 600V, 1μμf tolerance	Erie NPOK
C304	2-5793	Capacitor, ceramic, .001μf, 1000V, 20%	Centralab DD102
C305	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C306 & C307		Same as C305	
C308	2-5706	Capacitor, glass, 2-18μμf	JFD VC4
C309		p/o special assembly	B/B
C310		Same as C304	
C311		Same as C305	
C312		Same as C304	
C313		Same as C301	
C314	2-7250	Capacitor, ceramic, 1000μμf, 500V	Sprague 508C2
C315 & C317		Same as C308	
C318		Same as C309	
C319 & C320		Same as C304	
C321		Same as C308	
C323		Same as C301	
C324		Same as C314	
C325	2-4850	Capacitor, variable, air, 1.8-5.1μμf	Johnson 5MB11
C326		p/o special assembly	B/B
C329 & C330		Same as C304	
C331	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C333		Same as C331	
C334		Same as C301	
C335		Same as C314	
C336 & C337		Same as C304	
C338		Same as C325	
C339		Same as C326	
C340	2-5223	Capacitor, ceramic, 2.2μμf, 500V, 10%	Erie NPOK-2.2
C342	2-5671	Capacitor, ceramic, .001μf, 500V, 2%	Centralab SP1000
C343 & C344		Same as C342	
C347 thru C352		Same as C314	
C353		Same as C304	
*C801		.01μf	
*C802		200μμf	
*C803		100μμf	
*C804		.01μf	
*C805		.01μf	
C806	2-4966	Capacitor, composition, 3.6μμf, 500V, 5%	Stackpole GA,
CR301	8-7252	Diode, 1N68A	Hughes
CR801	8-8134	Diode, HD 6001	Hughes
J301	17-4985	Connector, coaxial	Automatic Metals UG1094/U UG1094/U
J302 & J303		Same as J301	
J304	17-4971	Connector, male, 7 pin	Amphenol 126-191
J307	17-7683	Connector, female, 2 pin	Elco F1022
L303	24-7694	Coil form w/loose collars	CTS PLS52C2L/N
L304 thru L306		Same as L303	
L307		Inductor	B/B
L308		Inductor	B/B
L310	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L311 thru L315		Same as L310	
*L801		100μh	
P301	17-6617	Connector, coaxial, UG88/U	Amphenol 31-002
P303		Same as P301	
P306		Same as P301	
P307	17-7684	Connector, male, 2 pin	Elco M3022
S301	12-1909	Switch, toggle, DPDT	CH8373K8
S302	17-7606	Switch, coaxial, SPDT	Danbury Knudsen CR26
T301	6-6448	Transformer, pulse	B/B
V301	5-0746	Tube, 6AH6	
V302 thru V306		Same as V301	
*V801		5749/6BA6W	
*V802		Same as V801	
XV301	4-0462	Socket, 7 pin	Cinch 13244
XV302 thru XV306		Same as XV301	
*XV801 & *XV802		Tube socket	

*Part of 22-4968 Oscillator Assembly

August 1960

OSCILLATOR & MULTIPLIER CHAIN SCHEMATIC DIAGRAM



BECKMAN/BERKELEY DIVISION
DWG. NO. 7580 D 3

PARTS LIST, TIME BASE MULTIPLIER & OSCILLATOR BINARY

Refer to Dwg. No. 7580 D 4

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

AB	Allen Bradley Company, Milwaukee, Wisconsin
B/B	Beckman/Berkeley, Richmond, California
IPC	Industrial Products Company, Danbury, Conn.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C401	2-2137	Capacitor, mica, 500μμf, 300V, 5%	Sangamo RR1350
C402	2-2142	Capacitor, mica, 250μμf, 500V, 5%	Sangamo RR1325
C403	2-5891	Capacitor, paper, 0.1μf, 400V, 20%	Hopkins P14D
C404	2-3505	Capacitor, mica, 330μμf, 500V, 5%	Sangamo RR1333
C405	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C406		Same as C404	
C407 & C408		Same as C401	
C409	2-5793	Capacitor, ceramic, .001μf, 1000V, 20%	Centralab DD102
C410 & C411		Same as C401	
C412	2-3624	Capacitor, mica, 220μμf, 500V, 5%	Sangamo RR1322
C413	2-3064	Capacitor, mica, 800μμf, 500V, 5%	Sangamo KR1380
C414		Same as C405	
C415		Same as C402	
C416	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C418		Same as C405	
C419		Same as C409	
C420		Same as C405	
C422	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C423		Same as C405	
C424		Same as C422	
C425		Same as C409	
C426		Same as C405	
C427	2-3619	Capacitor, ceramic, .0015μf, 600V, 10%	Erie 801-.0015
CR401	8-7560	Diode, HB6	Hoffman
CR402 thru CR407		Same as CR401	
CR408	8-7274	Diode, 1N198	Hughes
CR409		Same as CR408	
J401	17-4085	Connector, coaxial	Automatic Metals UG1094/U
J402 & J403		Same as J401	
L401	3-7251	Ferrite Beads	Ferroxcube 255 T 118 A 205
L402		Same as L401	
P401	17-2081	Connector, coaxial	IPC 3100 UG260/U
R401	1-1340	Potentiometer, 100K, 2W, 20%	AB JU5022 SD3048
S401	12-8049	Switch rotary	B/B
S402		Same as S401	
V401	5-6072	Tube, 6AN8	
V402	5-4764	Tube, 6922	
V403		Same as V402	
V404	5-0746	Tube, 6AH6	
V405		Same as V402	
V406	5-8050	Tube, 6476	
V407		Same as V406	
XV401	4-2973	Socket, 9 pin	Elco 377BC
XV402 & XV403		Same as XV401	
XV404	4-2972	Socket, 7 pin	Elco 316BC
XV405		Same as XV401	
XV406	4-8051	Socket, tube, counter	Sylvania 7460-0008
XV407		Same as XV406	

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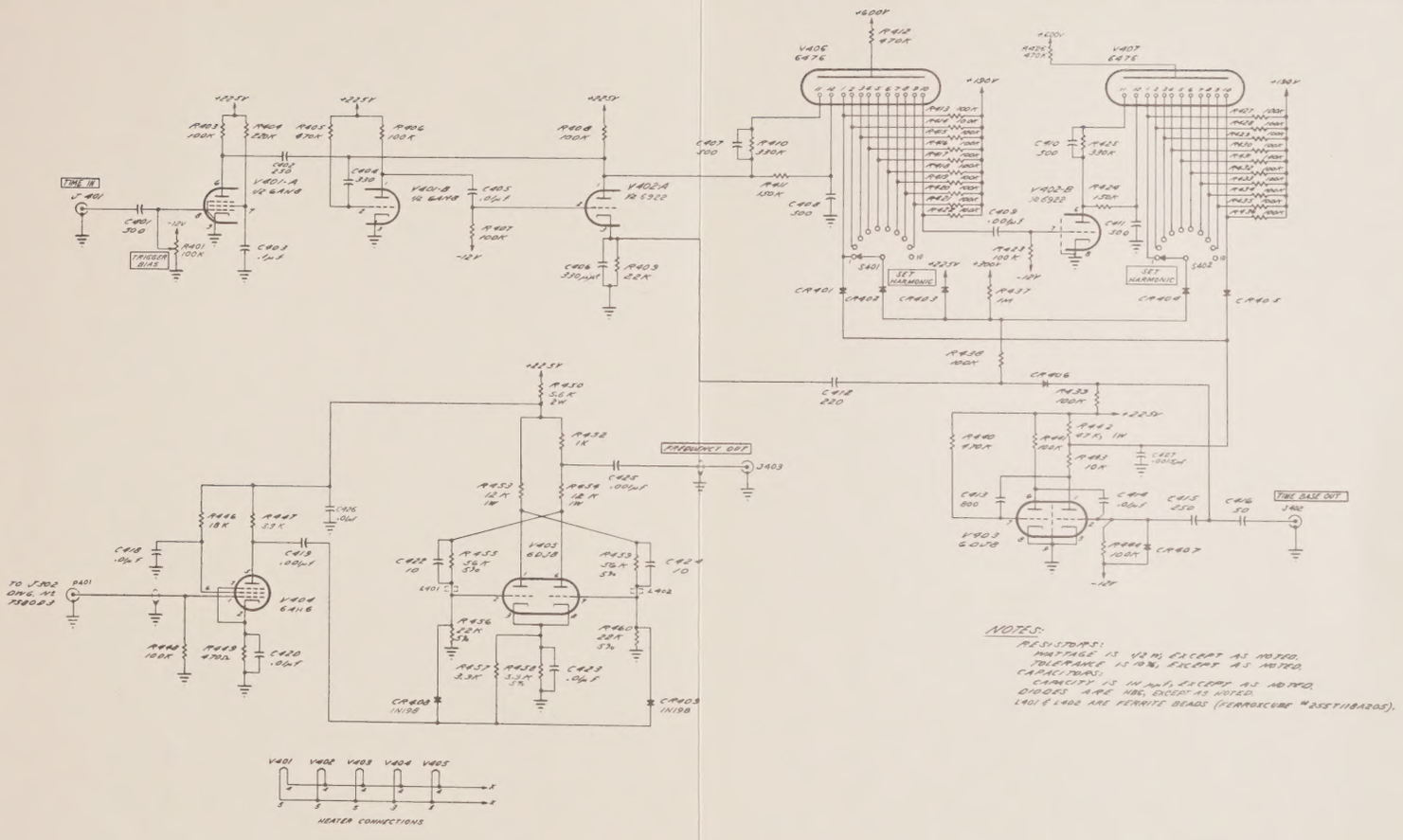
TIME BASE MULTIPLIER & OSCILLATOR BINARY SCHEMATIC DIAGRAM



NOTES:
RESISTORS:
WATTAGE IS 1/2 W, EXCEPT AS NOTED.
TOLERANCE IS 10%, EXCEPT AS NOTED.
CAPACITORS:
CAPACITY IS IN μμf, EXCEPT AS NOTED.
DIODES ARE HB6, EXCEPT AS NOTED.
L401 & L402 ARE FERRITE BEADS (FERROXCUBE "255T118A205").

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